# INFLUENCE OF PHOSPHORUS APPLICATION WITH OR WITHOUT NITROGEN ON OAT (*AVENA SATIVA*) GRASS NUTRITIVE VALUE AND *IN SITU* DIGESTION KINETICS IN BUFFALO BULLS

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## ABSTRACT

Fodder is the mainstay of ruminant production in majority of developing countries. However, its low yield and poor quality are considered considerable constrains which impede ruminant productivity. Fodder production and its nutritive value can be enhanced by ensuring adequate supply and utilization of nutrients in plant growth which is generally hampered by decreased or imbalanced proportion of P and/or nitrogen (N). The study was planned to examine the influence of phosphorus application with or without nitrogen on nutritive value and in situ digestion kinetics of oat (*avena sativa*) grass in *Nili Ravi* buffalo bulls. Nutritive composition data were analyzed by completely randomized design while *in situ* digestion kinetics data were analyzed by 4x4 latin square design using the general linear model. Oat grass seed was sown in lines using standard agronomic practices. The P fertilizer was applied at the rate of 0, 10, 15, 20, 25 and 30 kg/acre and treatments were denoted as control (C), P10, P15, P20, P25 and P30, respectively. Likewise, in independent fields along with P, N in an equal amount of P was also applied and treatments were represented as C, PN10, PN15, PN20, PN25 and PN30, respectively. Each treatment was applied on two hectares which were equally divided into three parts to serve as replicates. The dry matter (DM) and crude protein (CP) of oat fodder increased with increasing application of P with or without N. Findings of *in situ* nutrient digestibility indicated that rate of disappearance and extent of digestion of DM, CP, neutral detergent fiber (NDF), acid detergent fiber and hemicellulose increased. However, NDF and hemicellulose and lag time decreased with increasing application of P with or without N. Outcome of the study imply that nutritive value of oat grass increased with increasing P supplementation and similar observations were noticed for nutrient digestibility and rate of disappearance with or without N in buffalo bulls.

**Keywords:** Oat fodder, fertilization, nutritive value, digestion kinetics, bulls

## INTRODUCTION

In developing countries, fodder is considered a main ruminant feed which not only plays significant role to satisfy animal nutritional requirements but also narrow downs the gap between nutrient availability and demand through its conservation as silage and hay during fodder shortage periods (Shahzad et al., 2010). However, its low yield and poor quality in topical and subtropical countries is major factor which impedes ruminant productivity. The situation is getting worse because of diverting more acreage from fodder production to grain production to fulfill the dietary needs of ever increasing human population.

The reduced fodder yield and its low quality may be enhanced by applying improved agronomic practices. In this regard, use of chemical fertilizers can play significant role and can contribute to sustainable nutrient supply which is the considered main limiting factor in plant growth (Snyman, 2002). It has been observed that the use of nitrogen (N) and phosphorus (P) fertilizers have significant association with fodder growth, its yield and nutritive value (Messman, et al,. 1991). Seedlings development is critical in order to get optimum fodder yield (Grant, 2001) and plant may suffer from P deficiency during early vegetative stage (Saarela et al., 2003). Hence phosphorus fertilization is considered essential for early vegetative stage due to frequent insufficiency of P fertilizers in tropical soils. Whereas, N fertilizer causes significant improvement in plant height, number of leaves and stem diameter, resulting in increased plant dry matter (DM) yield and its N contents (Harvey et al., 1996; Caraballo et al., 1997; Ayub et al., 2007).

Oat grass (*Avena sativa*) is an important winter fodder cultivated both in irrigated and rain fed areas (Dost, 1997). It is single cut crop and supplies fodders during winter (November to March). It's yield is 75 to 80 tones per hector (Nazir et al., 1994). The ideal oat grass should have high CP and digestibility and low CF contents which can be obtained with the application of P with or without N fertilizer. However, information regarding the effect of P fertilizer application with or without N on its nutritive value is limited. Therefore, the present study was planned to examine the influence of P fertilizer application with or without N fertilizer on nutritive value and *in situ* digestion kinetics of oat grass in ruminally cannulated *Nili-Ravi* buffalo bulls.

## MATERIALS AND METHODS

### Sowing of oat fodder

The oat grass seed was purchased from local market and was sown in the fields of Livestock Experimental Station, Rakh Dera Chahl, Lahore, which exists on a latitude 31$^{o}$34'N and longitude 74$^{o}$22'E. The seed was sown in lines during mid of October. The seed rate was based on the pure standards of oat fodder. The fodder crop was sown with the help of a seed drill. The standard agronomic practices were followed during sowing of this fodder crop. The P and N fertilizers were applied at the time of sowing. The rate of P fertilizer was 0, 10, 15, 20, 25 and 30 kg/acre and these treatments were represented as control (C; sown without supplementation), P10, P15, P20, P25 and P30, respectively. In another plot N in an equal amount of P was also applied and treatments were represented as control

**Table 1.** Composition of oat fodder with or without supplementation of P fertilizer

| Items (%) | Treatments[1] | | | | | |
|---|---|---|---|---|---|---|
| | C | P10 | P15 | P20 | P25 | P30 |
| DM[2] | 22.36$^{b}$±0.15 | 22.89$^{a}$±0.31 | 22.91$^{a}$±0.28 | 23.18$^{a}$±0.47 | 23.11$^{a}$±0.70 | 23.05$^{a}$±0.39 |
| CP[3] | 6.56$^{d}$±0.13 | 7.00$^{cd}$±0.06 | 7.21$^{c}$±0.08 | 7.65$^{b}$±0.29 | 7.66$^{b}$±0.25 | 7.87$^{a}$±0.14 |
| NDF[4] | 48.00$^{a}$±0.72 | 46.00$^{b}$±0.69 | 45.0$^{bc}$±1.83 | 44.0$^{bc}$±0.64 | 42.00$^{c}$±0.64 | 41.00$^{d}$±0.85 |
| ADF[5] | 24.00±0.33 | 24.70±1.37 | 24.90±1.13 | 24.00±1.28 | 25.30±0.55 | 24.60±0.62 |
| HC[6] | 22.70$^{a}$±0.63 | 21.00$^{b}$±0.50 | 22.0$^{ab}$±0.24 | 9.40$^{c}$±0.66 | 17.30$^{d}$±0.50 | 16.10$^{d}$±0.43 |

Means in a row with different superscripts differ significantly ($P < 0.05$).
[1]C, P10, P15, P20, P25 and P30 represent 0, 10, 15, 20, 25 and 30kg P supplementation per acre, respectively. [2]Dry matter, [3]crude protein, [4]Neutral detergent fiber, [5]Acid detergent fiber, [6]Hemicellulose

(C; sown without supplementation), PN10, PN15, PN20, PN25 and PN30, respectively. Fertilizers were broadcasted by hand and then buried by a rake. The fodders were harvested after 100 days of age and fodder samples were carried to the Animal Nutrition Research Center, University of Agriculture, Faisalabad, which extends over latitude 31°30'N and longitude 73°05'E.

**Table 2.** Composition of oat fodder with or without supplementation of P and N fertilizers

| Items (%) | Treatments[1] | | | | | |
|---|---|---|---|---|---|---|
| | C | P10N10 | P15N15 | P20N20 | P25N25 | P30N30 |
| DM[2] | 22.36$^{c}$±0.62 | 24.60$^{b}$±0.31 | 25.30$^{ab}$±0.39 | 26.10$^{ab}$±0.54 | 26.70$^{a}$±0.50 | 26.90$^{a}$±1.01 |
| CP[3] | 6.56$^{d}$±0.38 | 8.65$^{c}$±0.14 | 9.10$^{b}$±0.40 | 9.70$^{ab}$±0.19 | 10.06$^{a}$±0.25 | 10.08$^{a}$ ±0.7 |
| NDF[4] | 45.00$^{a}$±0.57 | 40.00$^{b}$±0.53 | 37.00$^{c}$±0.35 | 36.00$^{c}$±0.65 | 36.00$^{c}$±0.36 | 33.00$^{d}$±0.58 |
| ADF[5] | 24.00$^{a}$±0.69 | 22.00$^{b}$±0.27 | 22.70$^{ab}$±0.38 | 21.00$^{c}$±0.74 | 20.80$^{c}$±0.30 | 20.80$^{c}$±0.79 |
| HC[6] | 21.00$^{a}$±0.61 | 18.00$^{b}$±0.36 | 14.30$^{c}$±0.36 | 15.00$^{c}$±0.11 | 15.20$^{c}$±0.18 | 12.20$^{d}$±0.32 |

Means in a row with different superscripts differ significantly ($P < 0.05$).
[1]C, P10N10, P15N15, P20N20, P25N25 and P30N30 represent 0, 10 kg P plus 10 kg N, 15 kg P plus 15 kg N, 20 kg P plus 20 kg N, 25 kg P plus 25 kg N, and 30 kg P plus 30 kg N supplementation per acre, respectively. [2]dry matter, [3]crude protein, [4]neutral detergent fiber, [5]acid detergent fiber

## Sample analyses

The fodder samples were dried and ground to 2mm size to determine chemical composition through chemical analysis and nutritive value by *in situ* digestion kinetics using cannulated *Nili Ravi* buffalo bulls. All samples of oat grass were analyzed for DM, CP, neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose according to the procedure described by AOAC (1990).

## *In situ* digestion kinetic study

For *in situ* digestion kinetics, fodder samples were ground to 2 mm size through a Wiley mill. Nylon bags measuring 10 x 23 cm (about 50 um pore size) were used in triplicate, 2 bags contained 10 g sample while third bag served as a blank. Four ruminally cannulated *Nili-Ravi* buffalo bulls were used in a 4 x 4 Latin Square Design. The bulls were kept on concrete floor in separate pens. Fresh and clean water was made available round the clock. The bulls were given 10 days adaptation period followed by four days of incubation period for in situ nylon bags. The bulls were fed the same fodder based diet as being incubated in their rumen during *in situ* trial. The nylon bags were soaked in distilled water ($39^{o}$C) for 15 minutes just before placing them into the rumen. The bags were then exposed to ruminal fermentation for 1, 2, 4, 6, 12, 24, 48, 72 and 96 hours, in reverse order and removed at the same time. Bags were then washed with running tap water until the rinse was clear. The bags were then dried in a forced air oven at $55^{o}$C for two days until constant weight. These bags were weighed again and residues were transferred to 100 mL cups and stored for later analysis. The DM, CP, NDF, ADF and hemicellulose of the residual materials were determined according to AOAC, (1990). *In situ* digestion kinetics parameters, i.e. rate and extent of degradation of DM, CP, NDF, ADF and hemicellulose and lag time were calculated for each period individually. Degradation rates were calculated by subtracting the indigestible residue i.e. 96h of ruminal incubation from the amount in the bag at each time point and then regressing natural logarithm of that value against time (Sarwar *et al.* 2004), after correcting for lag time (Mertens, 1977). The remaining percentage of DM, CP, NDF, ADF or hemicellulose at each incubation period was fitted to the model of nonlinear regression of Mertens and Loftens (1980). Ruminal disappearance and passage rate of DM, CP, NDF, ADF and hemicellulose were calculated according to Orskov and McDonald (1979). The NDF was determined using sodium sulphite and amylase [Van Soest *et al.* 1991 (method A for NDF)].

## Statistical analysis

The data of chemical composition were analyzed according to Completely Randomized Design while the data obtained from *in situ* digestion kinetics were analyzed as a 4x4 Latin Square Design using the general linear model procedure of SPSS (SPSS 10.0.1. 1999). In case of any significance, means were separated by Duncan's Multiple Range Test (Steel et al., 1997).

## RESULTS

Chemical composition of oat Supplemented with P fertilizer

Dry matter of oat fodder was significantly higher when it was supplemented with different levels of fertilizer as compared to control (Table1). Crude protein of oat fodder was significantly higher when it was supplemented with P30 followed by P20 and P25, P10 and P15 and P10 and control. The NDF was significantly lower in oat fodder supplemented with P30 while it was highest in control. However, ADF of fodder was similar across all treatments and did not show any effect of P supplementation. Hemicellulose of oat fodder supplemented with P30 and P25 was significantly lower as compared to control and other treatments (Table1).

Chemical composition of oat Supplemented with P and N fertilizer

The DM was significantly higher in oat fodder supplemented with higher levels of NP fertilizer (N15P15, N202P20, N25P25 and N30P30) as compared to control. However, DM was similar in oat fodder supplemented with N15P15, N20P20, N25P25 and N30P30 and N10P10 and N15P15, respectively (Table 2). Crude protein was significantly higher in oat fodder supplemented with higher levels of NP (N30P30, N25P25 and N20P20) followed by that supplemented with N20P20 and N15P15 and N10P10. However the CP was significantly lower in control. The NDF was significantly lowest in oat fodder supplemented with N30P30 while it was the highest in control. The ADF of oat was significantly lower in oat fodder supplemented with higher levels of NP (N30P30, N25P25 and N20P20) followed by that supplemented with medium levels of NP (N15P15 and N10P10), respectively. The ADF was the highest in control. Hemicellulose of oat fodder followed a similar trend as was observed in NDF.

Effect of N fertilizers on *in situ* digestion kinetics of oat fodder

Ruminal DM and CP degradation were significantly higher in oat fodder supplemented with P20 and P25, followed by that supplemented with P30, P15 and P10, respectively. The lowest DM and CP degradabilities were observed in oat fodder sown without supplementation. The NDF degradability at 48 hrs of incubation did not show and supplementation effect. Ruminal degradation of ADF was the highest in oat fodder supplemented with P30, P20 and P15 followed by that supplemented with P25 and P15, respectively. Significantly lowest ADF degradation was observed in oat fodder sown without supplementation. Hemicellulose degradation of oat fodder supplemented with higher levels of P (P30 and P25) was the highest significantly followed by that supplemented with medium P (P25, P20, P15 and P10) supplementation levels (Table 3).

**Table 3**: Effect of P fertilizers on oat in situ digestibility at 48h in bulls

| Items | Treatments[1] | | | | | |
|---|---|---|---|---|---|---|
| (%) | C | P10 | P15 | P20 | P25 | P30 |

| | | | | | | |
|---|---|---|---|---|---|---|
| DM[2] | 60.27[c]±0.59 | 62.94[bc]±0.90 | 64.99[b]±0.91 | 68.33[a]±1.74 | 68.08[a]±0.90 | 65.37[b]±0.54 |
| CP[3] | 58.40[c]±0.86 | 59.08[b]±0.57 | 59.98[b]±1.19 | 64.94[a]±0.90 | 63.35[a]±1.20 | 62.41[ab]±0.6 |
| NDF[4] | 59.93±1.66 | 59.74±0.87 | 59.57±0.68 | 61.62±1.18 | 59.75±1.11 | 60.98±2.41 |
| ADF[5] | 55.09[d]±0.66 | 59.68[c]±1.87 | 65.13[ab]±0.42 | 67.25[a]±0.51 | 62.87[b]±1.00 | 66.46[a]±0.59 |
| HC[6] | 52.07[c]±1.41 | 57.88[b]±2.08 | 58.55[b]±0.76 | 58.55[b]±0.40 | 60.08[ab]±1.29 | 62.86[a]±0.27 |

Means in a row with different superscripts differ significantly ($P < 0.05$).
[1]C, P10, P15, P20, P25 and P30 represent 0, 10, 15, 20, 25 and 30kg P supplementation per acre, respectively. [2]Dry matter, [3]crude protein, [4]Neutral detergent fiber, [5]Acid detergent fiber, [6]Hemicellulose

Effect of N and P fertilizers on *in situ* digestion kinetics of oat fodder

Ruminal DM degradability was significantly higher in oat fodder supplemented with N20P20 compared to control and other supplemented levels of NP fertilizers. Ruminal DM degradation was similar in oat fodder supplemented with N30P30, N25P25 and N15P15 and N10P10 and control. Ruminal degradation of CP was the highest in oat fodder supplemented with N30P30 and N25P25 and the lowest significantly in that supplemented with N15P15, N10P10 and control (Table 4). The NDF degradation was significantly higher in all NP supplemented oat fodder as compared to control (Table 4). Ruminal degradation of ADF was the highest in oat fodder supplemented with higher NP (N30P30 and N25P25) followed by that supplemented with medium (N20P20 and N15P15) and lower (N10P10 and control) NP supplementation levels. Hemicellulose degradation was the highest significantly in oat fodder supplemented with N30P30 and was lowest in oat fodder sown without supplementation (Table 4).

Digestion kinetics of Oat fodder Supplemented with P fertilizer

Dry matter extent at 96hrs of incubation was significantly higher in oat fodder supplemented with P25 and P20 and was lowest in P10 supplemented and controls (Table 5). The DM Lag (h) of oat fodder sown without supplementation was significantly higher as compared to other treatments (Table 5). However, DM lag was lowest in oat fodder supplemented with higher levels of P (P30, P25, P20 and P15). Rate of DM degradation was significantly higher in P25 and P20 supplemented oat fodder and was the lowest significantly in control (Table 5).

Extent of CP degradation was significantly higher in oat fodder supplemented with higher levels of P (P25 and P20) and was lower in P30, P15, P10 supplemented and control (Table 5). The CP Lag (h) of oat fodder sown without supplementation (control), P10 and P15 was significantly higher as compared to other treatments (Table 5). However, CP lag was the lowest significantly in oat fodder supplemented with highest level of P (P30). The CP rate of degradation was higher in oat fodder supplemented with P30, P25, P20 and P15 supplemented fodder and was the lowest significantly in control, P30, P15 and P10 supplemented fodder (Table 5).

**Table 4.** Effect of P and N fertilizers on *in situ* digestibility of oat at 48h in bulls

| Items (%) | Treatments[1] | | | | | |
|---|---|---|---|---|---|---|
| | C | P10N10 | P15N15 | P20N20 | P25N25 | P30N30 |
| DM[2] | 60.27$^{c}$±0.59 | 61.65$^{c}$±0.96 | 65.20$^{b}$.52 | 67.90$^{a}$±1.37 | 65.75$^{b}$±0.40 | 66.30$^{b}$±0.58 |
| CP[3] | 64.94$^{c}$±0.90 | 64.30$^{c}$±0.58 | 64.34$^{c}$±0.29 | 66.34$^{b}$±1.54 | 67.96$^{a}$±1.73 | 68.28$^{a}$±1.44 |
| NDF[4] | 59.93$^{b}$±1.66 | 60.66$^{a}$±0.88 | 59.42$^{a}$±0.44 | 60.37$^{a}$±0.44 | 61.13$^{a}$±1.11 | 62.32$^{a}$±1.15 |
| ADF[5] | 59.68$^{c}$±1.87 | 61.29$^{c}$±1.12 | 68.56$^{b}$±1.13 | 69.29$^{b}$±0.58 | 73.51$^{a}$±0.78 | 71.04$^{ab}$±0.4 |
| HC[6] | 51.88$^{d}$±0.44 | 54.50$^{c}$±1.01 | 55.25$^{bc}$±0.75 | 57.94$^{b}$±0.22 | 57.9 $^{b}$ ±2.18 | 61.57$^{a}$±0.45 |

Means in a row with different superscripts differ significantly ($P < 0.05$).
[1]C, P10N10, P15N15, P20N20, P25N25 and P30N30 represent 0, 10 kg P plus 10 kg N, 15 kg P plus 15 kg N, 20 kg P plus 20 kg N, 25 kg P plus 25 kg N, and 30 kg P plus 30 kg N supplementation per acre, respectively. [2]dry matter, [3]crude protein, [4]neutral detergent fiber, [5]acid detergent fiber

Extent of NDF degradation was significantly higher in oat fodder supplemented with higher levels of P (P30, P25 and P20) followed by that of supplemented with P15, P10 and was the lowest in control (Table 5). The NDF lag was the highest in oat fodder sown without supplementation while it was the lowest in oat fodder supplemented with higher levels of P (P30, P25 and P20). The NDF rate of degradation was significantly higher in oat fodder supplemented with P25 compared to control (Table 5).

Extent of ADF degradation was significantly higher in oat fodder supplemented with higher levels of P (P30, P25, P20, P15 and P10) and was the lowest in control (Table 5). The ADF Lag (h) showed an inverse trend as was observed in ADF extent of degradation. The ADF lag was the highest in oat fodder sown without supplementation while it was the lowest in oat fodder supplemented with higher levels of P (P30, P25, P20 and P15). The ADF rate of degradation was significantly higher in oat fodder supplemented with P25, while it was non-significant in that of supplemented with P30, P20 and P15 and P10 and control (Table 5). However, ADF rate of degradation was significantly lower in oat fodder supplemented with P10 and control.

Hemicellulose extent of degradation was significantly higher in oat fodder supplemented with higher levels of P (P30, P25 and P20) and was the lowest in P10 and control (Table 5). The Hemicellulose Lag (h) illustrated an inverse trend as was observed in its extent of degradation in situ (Table 5). Hemicellulose rate of degradation was significantly higher in oat fodder supplemented with P25 and P20, while it was non-significant in that supplemented with P30 and P15 and P10 and control (Table 5). However, rate of hemicellulose degradation was significantly lower in oat fodder supplemented with P10 and control.

Digestion kinetics of Oat fodder Supplemented with N and P fertilizer

The extent of DM degradation at 96hrs of incubation was significantly higher in oat fodder supplemented with N25P25 and N20P20 fertilizers and was the lowest significantly in N10P10 supplemented oat and control (Table 6). The DM Lag (h) of oat fodder sown without supplementation and N10P10 was significantly higher as compared to other treatments (Table 6). However, DM lag was the lowest statistically in oat fodder supplemented with higher levels of NP (N30P30, N25P25 and N20P20) fertilizers. Rate of DM degradation was significantly higher in N20P20 supplemented oat fodder and was the lowest significantly in control (Table 6). Extent of CP degradation was significantly higher in oat fodder supplemented with higher levels of NP (N30P30 and N25P25) fertilizers followed by that of supplemented with N20P20 and N15P15 and was the lowest in N10P10 supplemented and control (Table 6). The CP Lag (h) of oat fodder sown without supplementation was significantly higher as compared to other treatments while it was the lowest significantly in oat fodder supplemented with N25P25 (Table 6). The CP rate of degradation was significantly higher in oat fodder supplemented with N25P25 and was the lowest in control (Table 6). Extent of NDF degradation was significantly higher in oat fodder supplemented with all levels of NP fertilizers and was the lowest in control (Table 6). The NDF Lag (h) showed an inverse trend as was observed in NDF extent of degradation (Table 6). The NDF lag was the lowest in oat fodder supplemented with higher levels of NP fertilizers (N30P30 and N25P25) followed by N20P20 and N15P15 and N10P10 and N20P20 and was the highest in control. The NDF rate of degradation was significantly higher in oat fodder supplemented with N25P25 (Table 6). Extent of ADF degradation was significantly higher in oat fodder supplemented with all the levels of NP fertilizer and was the lowest in control (Table 6). The ADF lag was the highest in oat fodder supplementation with N15P15 while it was the lowest in that supplemented with higher levels of NP (N30P30 and N25P25) fertilizers. The ADF lag was similar across oat fodder supplemented with N30P30 and N25P25 and N20P20 and control (Table 6). The ADF rate of degradation was significantly higher in oat fodder supplemented with N25P25 followed by that of supplemented with N20P20, N30P30, N15P15, respectively while it was the lowest in N10P10 supplemented fodder and control. The extent of hemicellulose degradation was significantly higher in oat fodder supplemented with all levels of NP supplementation as compared to control (Table 6). Hemicellulose Lag (h) illustrated an inverse trend as was observed in extent of degradation *in situ*. It was higher in oat fodder supplemented with N10P10 and control followed by N15P15 and N20P20 and N25P25 and N30P30, respectively. Hemicellulose rate of degradation was significantly higher in oat fodder supplemented with N25P25 fertilizer compared to control (Table 6). However, hemicellulose rate of degradation was significantly lower in oat fodder supplemented with N10P10 and control.

**Table 5.** Effect of P fertilizers on *in situ* digestion kinetics of oat in buffalo bulls

| Items | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | C | P10 | P15 | P20 | P25 | P30 |
| Dry matter | | | | | | |
| Extent, % | $69.60^{c}\pm0.27$ | $69.57^{c}\pm0.32$ | $73.77^{b}\pm0.29$ | $75.23^{a}\pm0.38$ | $74.33^{a}\pm0.61$ | $73.28^{b}\pm0.68$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| Lag, h | 5.15$^{a}$±0.59 | 4.48$^{b}$±0.59 | 3.94$^{bc}$±0.30 | 3.51$^{c}$±0.46 | 4.13$^{bc}$±0.21 | 3.18$^{c}$±0.29 |
| Rate, %/h | 3.14$^{c}$±0.33 | 4.22$^{b}$±0.16 | 4.15$^{b}$±0.25 | 4.63$^{a}$±0.55 | 4.81$^{a}$±0.61 | 4.05$^{b}$±0.05 |
| Crude protein | | | | | | |
| Extent, % | 68.15$^{c}$±0.46 | 69.82$^{bc}$±0.57 | 70.74$^{b}$±0.57 | 73.61$^{a}$±0.53 | 74.53$^{a}$±0.30 | 71.35$^{b}$±1.02 |
| Lag, h | 5.88$^{a}$±1.50 | 5.35$^{ab}$±0.63 | 5.25$^{ab}$±0.90 | 4.64$^{b}$±0.40 | 3.03$^{c}$±1.11 | 2.30$^{d}$±0.45 |
| Rate, %/h | 3.93$^{b}$±0.19 | 3.71$^{b}$±0.26 | 4.37$^{ab}$±0.33 | 5.17$^{a}$±0.37 | 5.12$^{a}$±0.47 | 4.40$^{ab}$±0.30 |
| Neutral detergent fiber | | | | | | |
| Extent, % | 68.72$^{d}$±0.34 | 70.49$^{c}$±0.36 | 73.27$^{b}$±0.64 | 76.67$^{a}$±0.88 | 77.10$^{a}$±0.34 | 76.41$^{a}$±0.23 |
| Lag, h | 6.45$^{a}$±0.21 | 5.23$^{b}$±0.94 | 4.63$^{c}$±0.65 | 2.53$^{d}$±0.60 | 2.61$^{d}$±0.39 | 2.43$^{d}$±0.54 |
| Rate, %/h | 3.49$^{d}$±0.32 | 3.64$^{cd}$±0.33 | 3.99$^{c}$±0.40$^{b}$ | 4.59$^{b}$±0.28 | 5.20$^{a}$±0.35 | 4.79$^{b}$±0.10 |
| Acid detergent fiber | | | | | | |
| Extent, % | 66.89$^{b}$±0.28 | 69.08$^{a}$±0.41 | 69.86$^{a}$±1.08 | 68.90$^{a}$±0.36 | 68.09$^{ab}$±0.13 | 69.09$^{a}$±0.46 |
| Lag, h | 5.63$^{a}$±1.30 | 4.06$^{b}$±2.41 | 3.34$^{c}$±0.06 | 3.34$^{c}$±0.06 | 2.71$^{cd}$±0.63 | 2.29$^{d}$±0.41 |
| Rate, %/h | 3.34$^{c}$±0.10 | 3.42$^{c}$±0.25 | 4.06$^{b}$±0.45 | 4.26$^{b}$±0.13 | 5.60$^{a}$±0.60 | 3.94$^{b}$±0.24 |
| Hemicellulose | | | | | | |
| Extent, % | 65.90$^{c}$±0.32 | 66.44$^{c}$±0.60 | 68.87$^{b}$±0.64 | 71.60$^{a}$±0.83 | 72.20$^{a}$±0.86 | 71.69$^{a}$±0.76 |
| Lag, h | 5.57$^{a}$±0.51 | 4.48$^{b}$±0.29 | 4.62$^{b}$±0.98 | 4.47$^{b}$±0.26 | 3.70$^{c}$±0.34 | 2.51$^{d}$±0.52 |
| Rate, %/h | 3.32$^{c}$±0.18 | 3.46$^{c}$±0.35 | 3.90$^{b}$±0.17 | 4.89$^{a}$±0.57 | 4.93$^{a}$±0.40 | 4.01$^{b}$±0.21 |

Means in a row with different superscripts differ significantly ($P < 0.05$).

[1]C, P10, P15, P20, P25 and P30 represent 0, 10, 15, 20, 25 and 30kg P supplementation per acre, respectively.

**Table 6.** Effect of P and N fertilizers on *in situ* digestion kinetics of oat in bulls

Means in a row with different superscripts differ significantly ($P < 0.05$).

| Items | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | C | P10N10 | P15N15 | P20N20 | P25N25 | P30N30 |
| Dry matter | | | | | | |
| Extent, % | 69.60$^{c}$±0.27 | 69.47$^{c}$±0.58 | 70.70$^{bc}$±0.66 | 74.24$^{a}$±0.77 | 74.34$^{a}$±0.87 | 71.73$^{b}$±0.51 |
| Lag, h | 5.33$^{a}$±058 | 5.15$^{ab}$±0.59 | 4.59$^{b}$±0.31 | 3.86$^{bc}$±0.34 | 4.08$^{bc}$±0.12 | 3.14$^{c}$±0.30 |
| Rate, %/h | 3.45$^{d}$±0.57 | 3.91$^{c}$±0.37 | 4.53$^{b}$±0.22 | 4.81$^{a}$±0.61 | 4.52$^{b}$±0.26 | 4.58$^{b}$±0.08 |
| Crude protein | | | | | | |
| Extent, % | 68.15$^{c}$±0.46 | 72.77$^{c}$±1.62 | 73.78$^{b}$±0.69$^{a}$ | 74.20$^{b}$±0.87 | 78.36$^{a}$±2.08 | 77.77$^{a}$±2.76 |
| Lag, h | 4.01$^{a}$±0.18 | 3.50$^{b}$±0.62 | 2.72$^{c}$±1.24 | 2.70$^{c}$±1.13 | 2.09$^{d}$±0.92 | 2.30$^{cd}$±0.45 |
| Rate, %/h | 3.38$^{d}$±0.39 | 3.71$^{c}$±0.27 | 3.78$^{c}$±0.19 | 4.73$^{b}$±0.22 | 5.12$^{a}$±0.47 | 4.62$^{b}$±0.45 |
| Neutral detergent fiber | | | | | | |
| Extent, % | 68.72$^{c}$±0.34 | 73.55$^{b}$±0.66 | 76.83$^{ab}$±1.10 | 77.76$^{a}$±1.77 | 78.80$^{a}$±0.79 | 80.12$^{a}$±1.85 |
| Lag, h | 4.82$^{a}$±0.44 | 3.63$^{b}$±0.33 | 3.51$^{b}$±0.31 | 3.17$^{c}$±0.54 | 2.42$^{d}$±0.06 | 2.61$^{d}$±0.39 |
| Rate, %/h | 3.05$^{c}$±0.34 | 3.06$^{c}$±0.03 | 3.18$^{c}$±0.11 | 4.70$^{b}$±0.45 | 5.20$^{a}$±0.35 | 4.57$^{b}$±0.23 |
| Acid detergent fiber | | | | | | |
| Extent, % | 69.08$^{b}$±0.41 | 72.73$^{a}$±0.97 | 72.74$^{a}$±1.23 | 72.38$^{a}$±0.72 | 73.55$^{a}$±1.41 | 73.23$^{a}$±0.82 |
| Lag, h | 3.34$^{c}$±0.06 | 4.56$^{b}$±0.19 | 6.11$^{a}$±0.39 | 3.69$^{c}$±0.13b | 1.69$^{d}$±0.40$^{d}$ | 1.22$^{d}$±0.53 |
| Rate, %/h | 2.67$^{e}$±0.13 | 2.71$^{e}$±0.12 | 3.06$^{d}$±0.00 | 4.54$^{b}$±0.15 | 5.60$^{a}$±0.60 | 4.10$^{c}$±0.01 |
| Hemicellulose | | | | | | |
| Extent, % | 67.67$^{c}$±0.46 | 68.87$^{bc}$±0.64 | 69.40$^{b}$±0.59 | 71.69$^{ab}$±0.50 | 71.26$^{ab}$±1.52 | 72.66$^{a}$±0.40 |
| Lag, h | 3.91$^{a}$±0.23 | 3.77$^{a}$±0.19 | 3.54$^{b}$±0.18 | 3.47$^{b}$±0.13 | 2.31$^{c}$±0.48 | 2.51$^{c}$±0.52 |
| Rate, %/h | 2.80$^{d}$±0.17 | 2.77$^{d}$±0.23 | 3.63$^{c}$±0.25 | 4.55$^{b}$±0.23 | 4.93$^{a}$±0.40 | 4.24$^{b}$±0.08 |

[1]C, P10N10, P15N15, P20N20, P25N25 and P30N30 represent 0, 10 kg P plus 10 kg N, 15 kg P plus 15 kg N, 20 kg P plus 20 kg N, 25 kg P plus 25 kg N, and 30 kg P plus 30 kg N supplementation per acre, respectively.

## DISCUSSION

### Chemical composition

Messman et al. (1991) reported that fertilization of grasses with N and P fertilizers increased fodder yield and its nutritive value. However, P fertilization is considered essential to develop fodder seedlings during early growth stage (Saarela et al., 2003) due to its insufficiency in tropical soils. The results of the current study have revealed that supplementation of oat fodder with P fertilizer caused a significant improvement in its DM. The findings of the current study

were consistent with Dwivedi et al. (2003) who reported that application of P fertilizer to cowpea fodder improved its DM yield by 21 to 27% compared to that of sown without P fertilization. Pant et al. (2004) also observed higher forage yield with application of P fertilizer than control. They also reported that using low P (10kg P/ hectare/ year) improved forage production reducing accumulation of P in the soil. It might be due to the reason that tropical soils are deficient in P and the additional P supply through fertilizer is stored/ fixed in the soil. This fixed P becomes available slowly, and may be used to meet P requirements of developing seedlings of the fodder.

Supplementation of oat fodder with NP fertilizer also caused a significant improvement in nutritive value. Dwivedi et al. (2003) reported that application of NP fertilizers (90 kg N/ ha and 40 kg P/ha) resulted in higher DM and CP production than application of N or P fertilizer alone. Similarly, Sood and Singh (1986) observed that the use of NP fertilizer not only increased the biomass yield of grasses (Dichanthium Annulatum and Cenchrus Sigerus Vahl) but also improved their nutritive value. They further justified that supplementation of NP fertilizers results in improvement of NP status of the soil and also enhanced the yield of fodder (Khan et al., 2000) by providing essential nutrients for plant growth. The need for NP is pre-requisite for metabolic processes occurring in the plant, so supplementation of NP fertilizers resulted in improved vegetative growth and nutritive value. Moreover, application of NP fertilizer favors transformation of carbohydrates into protein (Khan et al., 2000) thus improving the nutritive value of the plant.

*In situ* digestibility Oat fodder Supplemented with N and P fertilizer

Results of the current study have supported the findings of the Puoli et al. (1991) who reported that DM and NDF digestibilities were higher in switch grass fertilized with N plus Sulfur fertilizers. This might be due to positive impact of N fertilization on growth of the grass which improved its DMD due to decrease in ruminal retention time. Contrary to these, Johnson et al. (2001) did not find any effect of N fertilization (0, 39, 78, 118 and 157 kg N/hac) on in vitro organic matter digestibility of bahia grass whereas digestibility of star grass was increased linearly and Bermuda grass quadratically with increasing levels of N fertilization. Similarly, Hughes and Haslemore (1981) reported that application of N fertilizer had non-significant effect on CP digestibility in oat forage. Whereas, Nichols (1990) observed that N fertilization (135 kg N /hac) decreased 5.2 % digestibility of meadow vegetation compared to those without N fertilization. This decrease in digestibility was due to formation of stein tissues which constitute 70% of the crop weight and is characterized with lower digestibility.

The supplementation of oat fodder with N and P fertilizers had positive impact on its nutritive value and digestibility. But the highest levels of phosphorus failed to improve quality of the fodder. Ruminal DM, CP, NDF, ADF and hemicellulose lag time was lower in bulls fed fodder sown with application of P or PN fertilizers compared to those sown supplementation. The probable reason may be that the supplementation of P or PN fertilizers improved nutritive value of the fodder by improving DM and CP which enhanced its utilization by the

animals and hence the digestibility was higher. It was also reported that N fertilization affected the N contents of the plant and increased degradation rate of NDF due to increased CP contents of timothy grass (Nordheim and Volden, 2009). Increasing levels of N fertilization also resulted in higher degradation rate of cell walls (Belanger and McQueen, 1999; Valk et al., 1996). The results of current study also supported the findings of Puoli et al. (1991) who reported that N fertilization reduced DM and NDF ruminal turnover times. Similarly, Romero et al. (1976) found that supplementing N increased digesta rate of passage out of the rumen, increased dietary N intake and stimulates rumen microbial growth (Preston and Leng, 1987; Poppi and McLennan, 1995) resulting in increased rate of disappearance, extent of digestion and lower lag time. In contrast, Messman et al. (1991) found that N fertilization had no effect on extent of fiber digestion. Cell wall contents and their digestibility remained unaffected with N fertilization (Deinum, 1984).

## Conclusion

Outcome of the study imply that nutritive value of oat increased with increasing P supplementation and similar observations were noticed for fodder nutrient digestibility and rate of disappearance with or without N in buffalo bulls.

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